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SUBLIMATION DRYING OF LIQUID MATERIALS

IN BULK FORM

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TECHNICAL TRANSLATION

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SUBLIMATION DRYING OF LIQUID MATERIALS IN BULK FORM

by
Professor A. S. Ginsburg and Engineer B. M. Lakhovitskiy
The Moscow Technological Institute
for the Food Industry

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SUBLIMATION DRYING OF LIQUID MATERIALS
IN BULK FORM

Sublimation drying of food products and biological materials has undergone considerable development over the last few years.

An analysis of drying methods now in existence and designs of sublimation apparatus has revealed that the intensification of the process was brought about basically by change in the system and as a result of the adoption of varying designs of condensers.

Future intensification of the process can be realized through preliminary operations which have received little or no attention up to now. Prior to drying (during the period of preliminary freezing), the material is given a shape which has the largest possible surface area. Increasing the surface area of the same volume of material makes it possible to reduce the time required for the process and, as a result, increases the technical and economic indices.

The sublimation drying process for both liquid and paste materials usually consists of two stages: preliminary freezing and drying proper. Spontaneous freezing is not possible for many materials due to the product's tendency to froth or splash and spatter. In addition to this, when the product is frozen spontaneously, a surface layer results which has a porous structure. This layer is a good insulator (due to the presence of pores), possessing low heat conductivity and thereby sharply reducing the ability of heat to permeate the material.

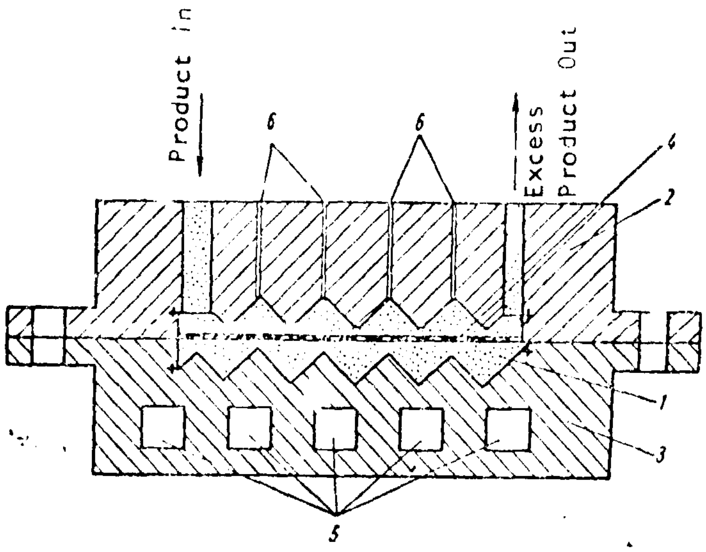
The existing method of sublimation drying of liquid and paste materials is accomplished using pans of varying designs, bottles and tubes. This method of drying has the following deficiencies: 1) the ratio of the material's

surface area to its volume is not optimum; 2) the material possesses a limited surface for moisture emission (sublimation), which means that for all practical purposes only the upper layer is involved in evaporation; 3) part of the energy radiation in the overall flow of energy is sharply reduced due to the fact that the jacket or covering cannot transmit electromagnetic waves of the appropriate diapason and heat is expended in warming up the pans, that is, the conductive component of the flow of heat is increased; 4) from the point of view of engineering, the presence of pans or flasks goes a long way in reducing the coefficient of effective priming volume for sublimation; 5) the process of filling or priming the pans and flasks with the material and emptying them periodically after each cycle by hand requires a considerable expenditure of labor.

The principle feature of the method being proposed, which was developed in the Moscow Technological Institute for the Food Industry lies in the fact that liquids and pastes are dried in blocks that are preliminarily frozen in special shapes.

The form for preliminary freezing in bulk form (Drawing 1) consists of two half molds which are fastened together with nails before the material is poured. The assembled mold forms the cavity into which the material flows and where it is then frozen. The upper half of the form has two holes for pouring the material and for excess liquid to run off. Both halves of the mold have channels through which the cooling agent circulates in order to freeze the material. In order to give the block stability during transportation and during the sublimation process, the freezing is done on a flat or volumetric screen or grid made of metal. The frames and screens can be made of nonmetallic materials if necessary. Instead of a screen, frames having partitions can also be used. The screens and frames not only act as the framework which insures the unit's massiveness, but also serve as an additional source of energy in the drying process.

Freezing the material in bulk form not only increases the surface area as a result of liquidation of the pans, but also acts to increase the surface area by corrugation. This is achieved by adopting a specially designed form for freezing the material.



Drawing 1. The mold used for preliminary freezing of units:
1- product; 2- upper half of the mold;
3- lower half of the mold; 4- screen;
5- channels through which the coolant passes; 6- holes for the escape of air.

Preliminary tests using ice to attempt to achieve an optimum shape or fo: of the unit or block showed that the intensity of evaporating the block depends on many factors: the angle between the corrugated ribs, the angle of the apex of the ribs, the width of the ribs, their shape and so on.

Naturally, the intensity of evaporation increases correspondently with the increase of surface area. At the same time, however, the increase of evaporation intensity is possible only within prescribed limits. During subsequent increase of surface area, the evaporation intensity remains constant and then decreases. This is explained by the fact that the overall surface increases while the active surface (that is, the surface area on which evaporation actually takes place) decreases.

The relationship of the coefficient of evaporation to the surface area of the material is shown in the table (Drawing 2) for several samples of shapes chosen at random. Based on the data shown in the table, sample number 5, which

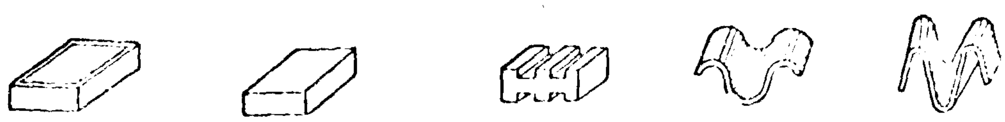
is manufactured in the form of a corrugated sheet having an angle of 90^{o} between corrugated ribs, is the one recommended. This unit ensures evaporation equal to $36.1 \times 10^{-5} kg/(M^{2}.sec)$

sample number	shape of sample	area of base $F.10^{-4}$, M^{2}	overall area $F.10^{-4}$, M^{2}	evaporation intensity $q_{M}.10^{-5}$, $kg/(M^{2}.sec)$	avg. amt. of moisture evaporation $Q_{M}.10^{-5}$, kg
1	shallow bowl......	126	126	13.3	1680
2	parallelepiped....	126	318	19.8	2500
3	block with square-cut grooves	126	563	26.5	3340
4	unit with rounded corrugated ribs...	126	470	29.4	3700
5	unit with parabolic ribs........	126	460	36.1	4550

The work project of a semi-manufacturing sublimation set-up for drying liquid and paste materials in bulk form was carried out by the Moscow Technological Institute for the Food Industry and the All-Union Scientific and Research Institute for the Fermentation and Alcohol Industry. A schematic of the apparatus is shown in Drawing 3.

This sublimation apparatus, which has a productive capacity of 40 kilograms per cycle, consists of the sublimator, condenser, product rack, refrigeration or cooling unit, vacuum pump and measuring devices. The sublimator is a welded unit, square in shape and has two detachable doors in the front part -- the lower one of organic glass used to charge the product and the upper one made of metal and used to get to the condenser unit. The interior of the sublimator is lined with plastic which possesses excellent reflectivity and is a heat insulator.

The rack for the product (Drawing 4), the condenser and refrigeration units, the tray for collecting the dried product, the tray for collecting water and ice from the condenser (during defrosting) are also located in the sublimator.



Nº1 Nº2 Nº3 Nº4 Nº5

Drawing 2. Shapes of samples used in the experiment.

The heating elements (220-volt, 40-watt SF-12 soffit-type lamps) are mounted in the rack or housing for the product. These lamps are secured in special clamps. There are 65 lamps in all in the apparatus.

When the rack is turned 90° the material can be desiccated in pans placed in a horizontal position. The condenser of the ribbed or corrugated type is fabricated in the form of a surface made up of copper tubes having a diameter of 12 X 1 mm. with brass ribs up to 1 mm. thick and spaced every 12 mm. The overall surface of the condenser is equal to 2.5 M^2. The condenser is fastened by bolts to two brackets welded to the sublimator duct.

The tray for collecting the water and ice is placed in the sublimator after the drying process is finished and the defrosting of the condenser begins.

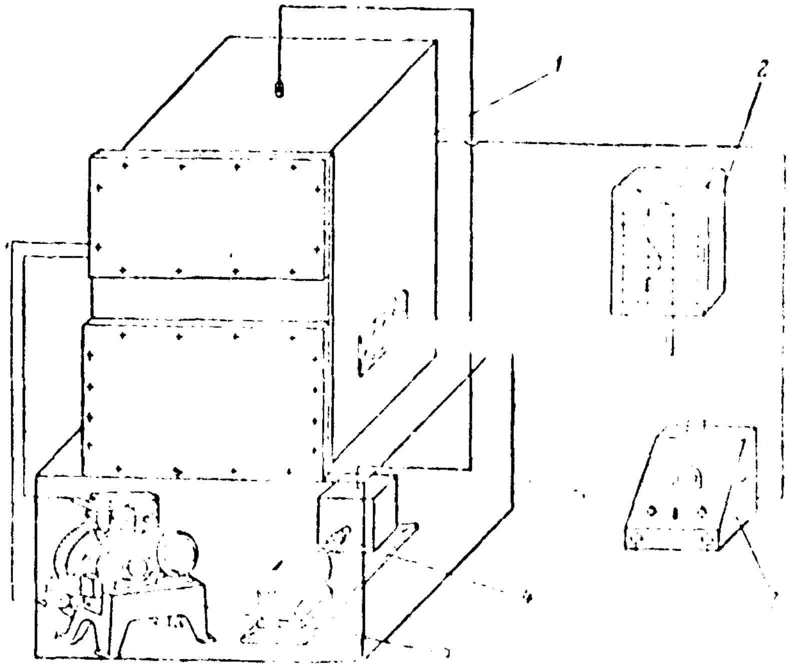
Suction filtering of the exhaust mixture is carried out by means of a gas-ballast vacuum pump, model VN-4M, through a fitting located in the ceiling of the sublimator.

Temperature control of the product, condenser and cooler, the infra-red heater and the interior of the sublimator is accomplished by means of chromel-copel thermocouples jacked into the electronic automatic self-adjusting potentiometer, model EPP-09.

A VT-2 vacuum gage with a thermopile manometric lamp, model LT-2 is used to control the pressure inside the sublimator. Pressure is regulated by means of an inlet or intake valve.

The frozen blocks are then placed in the product rack where they undergo desiccation. The finished product in

in powdered form is collected in a tray. After the ...



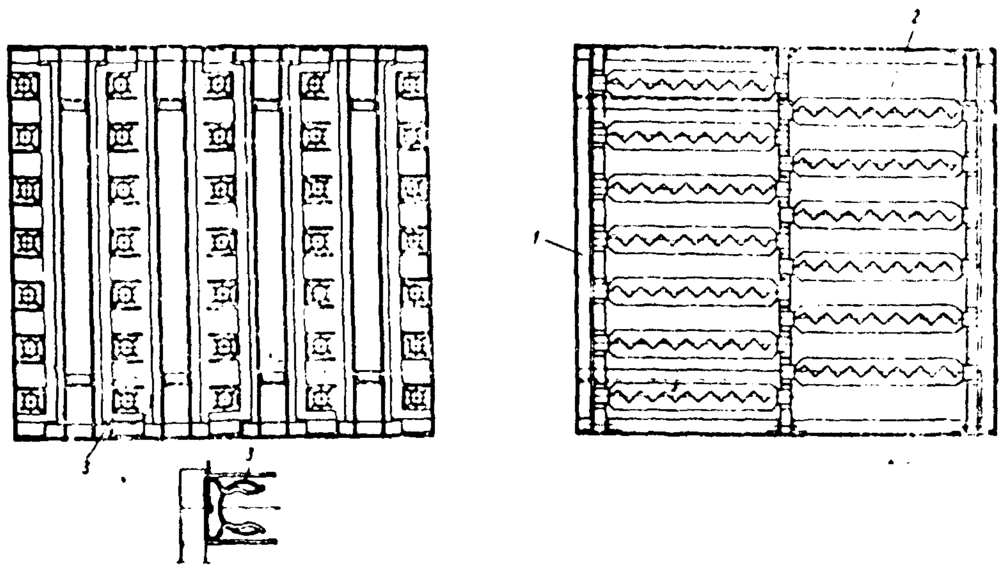
Drawing 3. Schematic of a sublimation unit assembly for desiccating liquid and paste forms of various materials:

1- the sublimator; 2- electronic potentiometer; 3- vacuum gage; 4- vacuum pump; 5- cooling apparatus.

process is completed, using special scrappers made of ... forated tubing fitted with brushes, the powder is then drawn off by means of a ventilator and is then collected from the dust extractor and placed in a hermetically-sealed carton.

In order to protect the material from contact with the air while the powder is being collected in the sublimator, nitrogen gas or other inert gases are used.

At the present time, work is going on in developing new designs for experimenting with different types of equipment in this field.



Drawing 4. Racks for the product:

1- the base; 2- soffit lamps, SF-12;
3- temperature control.

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13. ABSTRACT		

This article deals with sublimation drying of foods and biological materials. The method discussed here was developed by the Moscow Technological Institute for the Food Industry and utilizes a preliminary freezing process for the material, after which the material is placed in a sublimator in frozen form where the moisture is then removed by evaporation. The completed product is in powder form and is placed in hermetically-sealed cartons for storage.

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14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Kondensator (condenser)						
Zamorazhivaniye (freezing)						
Pastoobrazniy material (material in paste form)						
Poristaya struktura (porous structure)						
Sublimatsiya (sublimation)						
Ramki i setki (frames and screens)						
Intensivnost' ispareniya (intensity of evaporation)						
Soffit (soffit)						
Khromel'-kopelevyi (chromel-copel)						